PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-186924

(43)Date of publication of application : 09.07.1999

(51)Int.Cl. H04B 1/10

(21)Application number : 09-349804

(22)Date of filing : 18.12.1997

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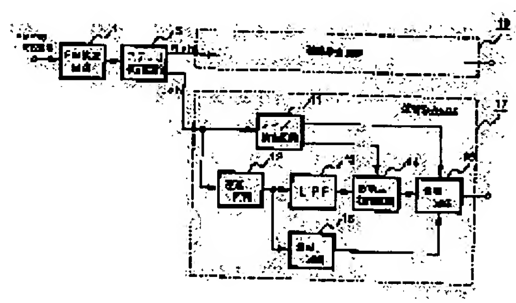
(54) NOISE ELIMINATION DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To eliminate pulse-like noise and to prevent the generation of discontinuity, before and after an elimination part by replacing the period of detecting noise by signals for which the output signals of an interpolation means for a low-band and the interpolation means for a high-band are synthesized.



SOLUTION: The output of an FM detection circuit 1 is supplied to a stereo demodulation circuit 5, and separated audio signals Lch and Rch are inputted to noise elimination circuits 17 and 18. In the noise elimination circuit 17, when a pulse-like noise is superimposed on the output audio signals of the stereo demodulation circuit 5 in a noise detection circuit 11, the output for indicating the timewise positions of the start and end is outputted to a polynomial interpolation circuit 14 and a synthesis circuit 16. A delay circuit 12 delays the audio signals, corresponding to time delay by a processing in the noise detection circuit 11, and a high-band component is removed in an LPF 13. The audio signals are inputted to the polynomial interpolation circuit 14, and interpolation is performed through polynomial interpolation for the period of detecting the pulse-like noise in the noise detection circuit 11.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Since in more detail removes the noise of the pulse nature resulting from an engine ignition plug, an engine window opening close drive motor, etc. in a car radio etc. with respect to noise rejection equipment, this invention uses it. Hereafter, this kind of noise is called "impulsive noise."

[0002]
[Description of the Prior Art] Drawing 24 is drawing showing the configuration of the conventional pulse nature noise rejection equipment of a publication in JP,63-87026,A. In drawing, the delay circuit 2 where the detection signal outputted from the FM detector circuit 1 which considers FM intermediate frequency signal of an FM receiver as an input consists of LPF (low pass filter) is supplied, it is delayed, and the output of a delay circuit 2 is supplied to the stereo demodulator circuit 5 through a gate circuit 3 and the level hold circuit 4. Moreover, a detection signal is supplied to HPF6 for noise detection (high-pass filter), and the noise component signal which passed HPF6 is amplified with the noise amplifier 7, and is supplied to the noise detector circuit 8.
[0003] It consists of a rectifier circuit which rectifies the output signal of the noise amplifier 7, and this noise detection output is supplied to a waveform shaping circuit 9 and an integrating circuit 10, and the noise detector circuit 8 changes a noise detection output into the pulse of predetermined time amount width of face, and supplies a waveform shaping circuit 9 to a gate circuit 3. A gate circuit 3 will be driven, will be in a signal cut off state, and at the time of a signal cut off state, the delay output level in front of signal cutoff is held by the level hold circuit 4, and it is supplied to the stereo demodulator circuit 5 by the pulse supplied to the gate circuit 3 from the waveform shaping circuit 9. Generating of the spike by sudden change of potential is prevented by this.
[0004] Moreover, an integrating circuit 10 forms an AGC loop formation by graduating a noise detection output, acquiring the direct current signal according to a noise level, and feeding back to the noise amplifier 7. In addition, the delay circuit 2 is formed in order to compensate time amount after impulsive noise is supplied to HPF6 until it makes a gate circuit 3 into a cut off state. Moreover, since it is inputted in the form where balanced modulation of a Lch (left channel) signal and the Rch (right channel) signal was carried out by the frequency of 38kHz the core [(Lch+Rch)/2] as the stereo demodulator circuit 5 shows to drawing 25 , Lch and Rch are separated and taken out by carrying out time sharing, for example by 38kHz.
[0005] Drawing 26 is drawing showing actuation of conventional noise rejection equipment. Supposing it is a signal including impulsive noise (sign A) as the output signal of the FM detector circuit 1 shows to drawing 26 (a), the signal which the high-frequency component of the output signal of the FM detector circuit 1 is extracted by HPF6, and is shown in this drawing (b) will be acquired. It is amplified with the noise amplifier 7 and rectified by the noise detector circuit 8, and the output signal of this HPF6 is changed into the pulse of predetermined time amount width of face as a waveform shaping circuit 9 shows to this drawing (c). The period of the impulsive noise of the predetermined signal time delay

carried out is controlled by the gate circuit 3 to a cut off state to be shown in this drawing (e) so that a delay circuit 2 shows to this drawing (d). In the level hold circuit 4, as shown in this drawing (f), when the level in front of cutoff holds the cutoff period of gate circuit 3 output, the impulsive noise which suited the signal of a basis is removed.

[0006]

[Problem(s) to be Solved by the Invention] As shown in drawing 27 (a) and (b), when impulsive noise is removed since conventional pulse nature noise rejection equipment was constituted as mentioned above, but a signal has a certain amount of amplitude, it does not mean a signal's becoming discontinuity immediately after maintenance, although it is last value maintenance therefore, and fully removing a noise. Moreover, although it is last value maintenance when a high frequency component is included, as shown in drawing 27 (c) therefore, a signal may become discontinuity maintenance order, and existence of an audibility top noise rejection processing part may be conspicuous. Furthermore, when a difference was in the signal of both channels as shown in drawing 27 (d) since before value maintenance processing was performed before the stereo recovery, there were troubles, such as producing the part which changes greatly to processing order in channel of one of the two with last value maintenance.

[0007] This invention was made in order to solve the above troubles, it removes impulsive noise from the audio signal after a stereo recovery certainly, and also when a high frequency component is moreover included, it aims at not producing discontinuous [of a removal part and order].

[0008]

[Means for Solving the Problem] A noise detection means to detect the noise which mixed the noise rejection equipment concerning this invention in the audio signal, The 1st delay means which gives the amount of delay in this noise detection means to the above-mentioned audio signal, The 1st filter means which extracts the low-frequency component of the audio signal output of this 1st delay means, A interpolation means for low-pass to perform polynomial interpolation about the period when the noise was detected by the above-mentioned noise detection means of the output of this 1st filter means, The 2nd delay means which gives the amount of delay in the above-mentioned interpolation means for low-pass to the audio signal output of the delay means of the above 1st, It has the signal composition means which substitutes the period when the noise was detected by the above-mentioned noise detection means of the audio signal of this 2nd delay means output with the output signal of the above-mentioned interpolation means for low-pass.

[0009] Moreover, a noise detection means to detect the noise mixed in the audio signal and the 1st delay means which gives the amount of delay in this noise detection means to the above-mentioned audio signal, The 1st filter means which extracts the low-frequency component of the audio signal output of this 1st delay means, A interpolation means for low-pass to perform polynomial interpolation about the period when the noise was detected by the above-mentioned noise detection means of the output of this 1st filter means, The 2nd delay means which gives the amount of delay in the above-mentioned interpolation means for low-pass to the audio signal output of the delay means of the above 1st, The 2nd filter means which extracts the high frequency component of the audio signal output of the delay means of the above 1st, A memory means to conserve the output of this 2nd filter means, and a interpolation means for high regions to read and interpolate the high frequency component of the period when the noise was detected by the above-mentioned noise detection means from this memory means, It has the signal composition means which substitutes the period when the noise was detected by the above-mentioned noise detection means of the audio signal output of the delay means of the above 2nd by the signal which compounded the output signal of the above-mentioned interpolation means for low-pass, and the output signal of the above-mentioned interpolation means for quantity regions.

[0010] Moreover, a noise detection means to detect the noise mixed in the audio signal and the 1st delay means which gives the amount of delay in this noise detection means to the above-mentioned audio signal, The 1st filter means which extracts the low-frequency component of the audio signal output of this 1st delay means, A interpolation means for low-pass to perform polynomial interpolation about the period when the noise was detected by the above-mentioned noise detection means of the output of this 1st filter means, The 2nd delay means which gives the amount of delay in the above-mentioned

interpolation means for low-pass to the audio signal output of the delay means of the above 1st, A frequency-analysis means to analyze the frequency component of the audio signal output of the delay means of the above 1st, The single or two or more frequencies which are in the frequency range intercepted with the filter means of the above 1st of the output signal in front of the period when the noise was detected by the above-mentioned noise detection means of this frequency-analysis means, and excelled below in the Nyquist rate are detected. The period when the noise was detected by the above-mentioned noise detection means of the audio signal output of a high-frequency component generation means to generate the sine wave of the frequency, and the delay means of the above 2nd It has the signal composition means substituted by the signal which compounded the output signal of the above-mentioned interpolation means for low-pass, and the output signal of the above-mentioned high-frequency component generation means.

[0011]

[Embodiment of the Invention] In the noise rejection equipment which is the gestalt of implementation of this invention, a low pass filter extracts the low-frequency component of an audio signal, polynomial interpolation of a low-frequency component is performed about the period when impulsive noise was detected, a interpolation signal is created, and it substitutes for the original audio signal about the period when impulsive noise was detected.

[0012] Moreover, a low pass filter extracts the low-frequency component of an audio signal, polynomial interpolation of a low-frequency component is performed about the period when impulsive noise was detected, and a low-pass interpolation signal is created. Moreover, a high pass filter extracts the high frequency component of an audio signal, it accumulates in sequential fixed period memory, the signal of the last past is read from memory about the period when impulsive noise was detected, and it considers as a high region interpolation signal. Finally a low-pass interpolation signal and a high region interpolation signal are compounded, and it substitutes for the original audio signal about the period when impulsive noise was detected.

[0013] Moreover, a low pass filter extracts the low-frequency component of an audio signal, polynomial interpolation of a low-frequency component is performed about the period when impulsive noise was detected, and a low-pass interpolation signal is created. Moreover, from the result of the frequency analysis to an audio signal, the single or two or more frequencies which stood high below with the Nyquist rate in the frequency range intercepted with a low pass filter about just before the period when impulsive noise was detected are detected, the sine wave of the frequency is generated, and it considers as a high region interpolation signal. Finally a low-pass interpolation signal and a high region interpolation signal are compounded, and it substitutes for the original audio signal about the period when impulsive noise was detected.

[0014] Hereafter, this invention is concretely explained based on the drawing in which the gestalt of that operation is shown.

Gestalt 1. drawing 1 of operation is the block circuit diagram of the noise rejection equipment which is the gestalt 1 of implementation of this invention. drawing -- setting -- 1 -- FM detector circuit and 5 -- for a delay circuit and 13, as for a polynomial interpolation circuit and 15, LPF and 14 are [a stereo demodulator circuit and 11 / a noise detector and 12 / a delay circuit and 16] synthetic circuits, and the noise limiter circuit 17 for a piece channel of the audio signal output of the stereo demodulator circuit 5 is constituted by these. 18 is the noise limiter circuit of another side, and since a configuration is completely identitas with 17, explanation is omitted.

[0015] In the gestalt 1 of this operation, FM detector circuit 1 output which considers FM intermediate frequency signal of an FM receiver as an input is supplied to the stereo demodulator circuit 5, is taken out as an audio signal divided into Lch and Rch, and is inputted into noise limiter circuits 17 and 18. In a noise limiter circuit 17, when impulsive noise has ridden on this in response to the audio signal of the output of the stereo demodulator circuit 5, the output which shows the time location of the initiation and termination is outputted to the polynomial interpolation circuit 14 and the synthetic circuit 16 in the noise detector 11. A circuit like the part constituted by the part 6 which generates the signal which controls the gate circuit 3 of the conventional example, for example as a noise detector 11, i.e., HPF, the

noise amplifier 7, the noise detector circuit 8, a waveform shaping circuit 9, and the integrating circuit 10 is raised. In a delay circuit 12, an audio signal is delayed corresponding to the time delay by processing in the noise detector 11. Delay circuit 12 output is inputted into LPF13, and a high-frequency component is removed. The audio signal which had the high-frequency component removed by LPF13 is inputted into the polynomial interpolation circuit 14, and is interpolated by polynomial interpolation about the period when impulsive noise was detected by the noise detector 11.

[0016] Drawing 2 is drawing explaining the case where interpolation by the 3rd formula is performed as an example of actuation of the polynomial interpolation circuit 14. The signal with which the original signal mixed (a) among drawing and the noise mixed (b), and (c) show the interpolated signal. A noise mixes in the period of $x1<x<x2$, and it has become the figure in which the original signal was missing. It interpolates by the 3rd polynomial of Lagrange who shows this period of x below.

[0017]

[Equation 1]

$$f(x)=\sum_{i=0}^{3} y_i\left(\frac{\prod_{j=0, j\neq i}^{3}(x-x_j)}{\prod_{j=0, j\neq i}^{3}(x_i-x_j)}\right)$$

[0018] In this case, the signal of the part which was missing each from two points before or after the period of impulsive noise is created, and as shown in this drawing (c), it interpolates.

[0019] Drawing 3 is drawing explaining the use of removing a high-frequency component by LPF13 before polynomial interpolation, and shows an example at the time of performing polynomial interpolation by the 3rd formula, without removing a high-frequency component. The signal with which the original signal mixed this drawing (a) and the noise mixed (b), and (c) show the interpolated signal. Since it is calculated from two each before and behind an impulsive noise period when a high-frequency component is included and it is vibrating, as shown in (a), interpolation greatly projected depending on conditions as shown in (c) may be carried out. If drawing 4 shows the case where LPF performs high-frequency component removal to the signal of drawing 3 and the high-frequency component is removed, it does not project greatly.

[0020] Drawing 5 shows an example of the concrete configuration of the polynomial interpolation circuit 14. It is constituted by ** holding circuit 14b and arithmetic circuit 14c which creates a interpolation signal based on Lagrange's 3rd polynomial from these four points immediately after holding two immediately after ** holding circuit 14a and an impulsive noise period, just before holding two in front of an impulsive noise period.

[0021] Drawing 6 is drawing for explaining the actuation, and the output of LPF13 turns (a), the noise detector 11 turns (b) polynomial interpolation circuit 14, and it is an output. Holding circuit 14a for just before holds two last points and the value of x0 and x1 based on the front edge of the detection result of the noise detector 11. Similarly holding circuit 14b for immediately after holds two next points, x2, and the value of x3 based on the back edge of a detection result. In arithmetic circuit 14c, the value of interpolation signal each point is computed based on Lagrange's 3rd polynomial, and it outputs so that it may become in phase with the signal compounded in the synthetic circuit 16. Although drawing 6 (c) shows the situation of polynomial interpolation, since the result of an operation cannot be taken out unless it comes after a point x3 in time in fact, a interpolation signal is delayed to a location as shown for example, in this drawing (d).

[0022] On the other hand, the output of a delay circuit 12 can give delay of the part which the output and timing of the polynomial interpolation circuit 14 suit by the delay circuit 15. The audio signal output of a delay circuit 15 and the interpolation signal output of the polynomial interpolation circuit 14 are inputted into the synthetic circuit 16, and based on the noise detection result of the noise detector 11, the noise part of an audio signal is substituted for a interpolation signal, and is compounded.

[0023] Drawing 7 is the explanatory view of actuation of the synthetic circuit 16. This drawing (a)

Drawing 6 already explained - (c) as actuation of the polynomial interpolation circuit 14. (c) is the interpolation signal of the output of the polynomial interpolation circuit 14. (d) is the audio signal which doubled (c) and timing by the delay circuit 15. The noise detector 11 is the output to turn synthetic circuit 16, and (e) has amended a delayed part in the polynomial interpolation circuit 14. The synthetic output shown in (f) is obtained by transposing to the interpolation signal of (c) to the impulsive noise period of (d) by (e).
[0024] Drawing 8 is drawing explaining the result of the gestalt 1 of this operation of operation, (a) expresses the original signal and the broken-line part shows between impulsive noise nascent states. (b) shows the result of operation by the gestalt 1 of this operation, and shows the case where polynomial interpolation is performed after high-frequency component removal. (c) shows the case where polynomial interpolation is performed without carrying out high-frequency component removal as a comparison, and has become the interpolation projected compared with (b).
[0025] In addition, although the gestalt 1 of operation explained the noise rejection to FM stereo signal, actuation is completely the same in the case of a monophonic signal only by the output of two lines of the FM demodulator circuit 5 completely serving as this signal. Moreover, since it is changeless to the processing after the audio signal output of the AM detector circuit 19 as shown in drawing 9 also to an AM signal, the configuration and actuation of a noise limiter circuit 17 are fundamentally the same.
[0026] Gestalt 2. drawing 10 of operation is the block circuit diagram of the noise rejection equipment which is the gestalt 2 of implementation of this invention, and shows that the same sign as drawing 1 is the same respectively, or a considerable part. drawing -- setting -- 1 -- FM detector circuit and 5 -- a stereo demodulator circuit and 12 -- a delay circuit and 13 -- LPF and 14 -- for a noise detector and 21, as for memory and 23, a high-pass filter (henceforth "HPF") and 22 are [a polynomial interpolation circuit and 15 / a delay circuit and 20 / a high region interpolation circuit and 24] synthetic circuits, and the noise limiter circuit 25 for a piece channel of the audio signal output of the stereo demodulator circuit 5 is constituted by these. 26 is the noise limiter circuit of another side, and since a configuration is completely identitas with 25, explanation is omitted.
[0027] Since actuation of the part 1 which overlaps the gestalt 1 of operation, i.e., FM detector circuit, the stereo demodulator circuit 5, a delay circuit 12, LPF13, and the polynomial interpolation circuit 14 is completely the same, explanation is omitted.
[0028] The output of a delay circuit 12 is inputted into HPF21, and a low-pass component is removed. By HPF21, the audio signal which had the low-pass component removed is inputted into memory 22, sequential storage is carried out, and constant-rate storing of the audio signal which had the low-pass component of the just before at the time of being always in memory 22 removed is carried out. In the high region interpolation circuit 23, a just before [the amount which buries the period] signal is taken out from memory 22 as a high region interpolation signal about the period when the impulsive noise of the output of the noise detector 20 was detected.
[0029] Drawing 11 is the explanatory view showing an example of actuation of the high region interpolation circuit 23 and memory 22. The broken line in this drawing shows the signal which should have original which was missing with impulsive noise. The approach of moving to the location which does not become discontinuity by the boundary point as shown in (b) since it may become discontinuity by the boundary point as shown in this drawing (a) if the last signal is taken out from memory 22 simply and fixed about the period when impulsive noise was detected in the high region interpolation circuit 23, and taking out is taken.
[0030] About the signal of a just before [the impulsive noise period which drawing 12 is drawing explaining an example of the concrete approach, and is stored in memory 22] field The level of the slope-of-a-line relation and the midpoint which connect 2 in front of an impulsive noise period and the physical relationship of A1 and A2, i.e., both points, is used. It goes back with the location as the starting point which returned from the point A2 by the same period as an impulsive noise period, two points, B1, and B-2 which confront each other by the same inclination relation on both sides of the level of this midpoint are calculated, and the signal for an impulsive noise period is taken out from immediately after point B-2.

[0031] Drawing 13 shows an example of the concrete configuration of the high region interpolation circuit 23, and constitutes it by memory read-out circuit 23a and control/judgment circuit 23b. The noise detector 20 turns high region interpolation circuit 23, and control/judgment circuit 23b makes the read-out initiation origin from memory 22 direct and read to memory read-out circuit 23a based on the noise detection location and width of face of an output. Performing the judgment explained by drawing 12 to the read-out result from memory read-out circuit 23a, a room top is gone back in the direction of time amount, and the signal for an impulsive noise period is read from immediately after the point which was able to be found, and it outputs so that it may become in phase with the output of the polynomial interpolation circuit 14 compounded in the synthetic circuit 24.
[0032] On the other hand, the output of a delay circuit 12 can give delay of the part which the output of the polynomial interpolation circuit 14 and the output of the high region interpolation circuit 19, and timing suit by the delay circuit 15. The audio signal output of a delay circuit 15, the low-pass interpolation signal output of the polynomial interpolation circuit 14, and the output of the high region interpolation circuit 23 are inputted into the synthetic circuit 24, and the noise detector 20 turns synthetic circuit 24, and based on the noise detection result of an output, the noise part of an audio signal is substituted for a interpolation signal, and is compounded.
[0033] Drawing 14 is the example of a concrete configuration of the synthetic circuit 24, and consists of adder-circuit 24a and electronic switch 24b. In adder-circuit 24a, the low-pass interpolation signal of the output of the polynomial interpolation circuit 14 and the high region interpolation signal of the output of the high region interpolation circuit 23 are added. In electronic switch 24b, the output of a delay circuit 15 and the output of adder-circuit 24a are changed and compounded based on the output of the noise detector 20.
[0034] Drawing 15 is drawing for explaining the timing of the polynomial interpolation circuit 14, the high region interpolation circuit 23, and a delay circuit 15. The noise detection result by the noise detector 20 and (b) (a) The output of a delay circuit 12, The noise detector 20 turns (c) polynomial interpolation circuit 14. An output and (d) The output of LPF13, and the low-pass interpolation signal output of the polynomial interpolation circuit 14, (e) is [the output of a delay circuit 15 and (i of the output to which the noise detector 20 turns to high region interpolation circuit 23, the output of HPF21 and the high region interpolation signal output of the high region interpolation circuit 23 turn an output and (f) to, and the noise detector 20 turns (g) synthetic circuit 24, and (h))] the outputs of the synthetic circuit 24. Generally, from HPF, the direction of LPF has the large amount of delay, and it comes out to the timing which was in the output of the polynomial interpolation circuit 14 in time. Therefore, the output of the high region interpolation circuit 23 and the output of a delay circuit 15 operate so that the output and timing of the polynomial interpolation circuit 14 may suit. Moreover, the noise detector 20 is outputted to the timing decided by time amount until a low-pass interpolation signal is outputted to the output of delay by the timing 13 it is decided fixed that will be each connection place, i.e., LPF, delay by HPF21, and the polynomial interpolation circuit 14.
[0035] Drawing 16 is drawing explaining the result of the gestalt 2 of this operation of operation, (a) expresses the original signal and the broken-line part shows between impulsive noise nascent states. (b) shows the result of operation by the gestalt 2 of this operation, compounds the low-pass interpolation signal which performed polynomial interpolation after high-frequency component removal, and the high region interpolation signal which took out the high-frequency component in the field in front of between impulsive noise nascent states, and is substituting it for the noise part of an audio signal.
[0036] In addition, although the gestalt 2 of operation explained the noise rejection to FM stereo signal, actuation is completely the same in the case of a monophonic signal only by the output of two lines of the FM demodulator circuit 5 completely serving as this signal. Moreover, since it is changeless to the processing after the audio signal output of the AM detector circuit 19 as shown in drawing 17 also to an AM signal, the configuration and actuation of a noise limiter circuit 25 are fundamentally the same.
[0037] Gestalt 3. drawing 18 of operation is the block circuit diagram of the pulse nature noise rejection equipment which is the gestalt 3 of implementation of this invention, and shows that the same sign as drawing 10 is the same respectively, or a considerable part. drawing -- setting -- 1 -- FM detector circuit

and 5 -- a stereo demodulator circuit and 12 -- a delay circuit and 13 -- for a delay circuit and 24, as for a noise detector and 27, a synthetic circuit and 26 are [LPF and 14 / a polynomial interpolation circuit and 15 / a frequency-analysis circuit and 28] high region generation circuits, and the noise limiter circuit 29 for a piece channel of the audio signal output of the stereo demodulator circuit 5 is constituted by these. 30 is the noise limiter circuit of another side, and since a configuration is completely identitas with 29, explanation is omitted.

[0038] Since actuation of the part 1 which overlaps the gestalt 1 of operation, i.e., FM detector circuit, the stereo demodulator circuit 5, a delay circuit 12, LPF13, and the polynomial interpolation circuit 14 is completely the same, explanation is omitted.

[0039] As a frequency-analysis circuit 27, FFT (Fast Fourier Transform), MDCT (Modified Discrete Cosine Transform), SBF (Sub bandFilter), etc. are specifically used, and distribution of a frequency is searched for by count.

[0040] It is inputted into the frequency-analysis circuit 27, frequency distribution of an audio signal is searched for, and the output of a delay circuit 12 detects and outputs the single or two or more frequencies which are in the frequency range intercepted by LPF13, and excelled below in the Nyquist rate. The high region generation circuit 28 generates the sine wave of the frequency which corresponds in response to the output of the frequency-analysis circuit 27, and doubles and outputs just before between [of the output of a delay circuit 15] noise nascent states, and a phase. Drawing 19 is drawing explaining actuation of the frequency-analysis circuit 27. This drawing (a) expresses the input of the frequency-analysis circuit 27, (b) expresses the frequency distribution searched for by frequency analysis, and the value of the frequency which stood high below with the Nyquist rate out of the frequency range through which LPF13 shown in drawing passes is outputted. In response to this value, a single or two or more sine waves are generated and outputted in the high region generation circuit 28. When a sine wave is plurality, it compounds and outputs.

[0041] Drawing 20 shows the example of a concrete configuration of the frequency-analysis circuit 27 and the high region generation circuit 28, the frequency-analysis circuit 27 consists of FFT circuit 27a and excellence cycle detector 27b, and the high region generation circuit 28 consists of sinusoidal generating circuit 28a and phase adjustment circuit 28b. FFT circuit 27a undergoes the audio signal output of a delay circuit 12, and as drawing 19 explained, it computes frequency distribution. Based on this frequency distribution, the value of the frequency which stood high below with the Nyquist rate in the frequency range intercepted by LPF is outputted by excellence cycle detector 27b. Therefore, from the frequency-analysis circuit 27, a value is outputted with the time interval which actuation of FFT circuit 27a and excellence cycle detector 27b takes.

[0042] In response to the output of the frequency-analysis circuit 27, sinusoidal generating circuit 28a generates a single or two or more sine waves, and, in two or more cases, compounds and outputs them. In phase adjustment circuit 28b, the phase of just before between [of the output of a delay circuit 15] noise nascent states and the output of sinusoidal generating circuit 28a is doubled and outputted in response to the high region generation circuit 28 and the output turned synthetic circuit 24 of the output of a delay circuit 15, and the noise detector 26.

[0043] Drawing 21 is drawing for explaining the timing of the polynomial interpolation circuit 14, the high region generation circuit 23, and a delay circuit 15. The noise detection result by the noise detector 26 and (b) (a) The output of a delay circuit 12, The noise detector 26 turns (c) polynomial interpolation circuit 14. An output and (d) The output of LPF13, and the low-pass interpolation signal output of the polynomial interpolation circuit 14, The output of a delay circuit 15 and (h of the output to which the input of the frequency-analysis circuit 27 and the output of the high region generation circuit 28 turn (e) to, and the noise detector 26 turns (f) synthetic circuit 24, and (g)) are the outputs of the synthetic circuit 24. Since it comes out to the timing which was in the output of the polynomial interpolation circuit 14 in time, the output of the high region generation circuit 28 and the output of a delay circuit 15 operate so that the output and timing of the polynomial interpolation circuit 14 may suit. Moreover, the noise detector 26 is outputted to the timing decided by time amount until a low-pass interpolation signal is outputted to the output of delay by the timing 13 it is decided fixed that will be each connection place,

i.e., LPF, and the polynomial interpolation circuit 14.
[0044] On the other hand, the output of a delay circuit 12 can give delay of the part which the output of the polynomial interpolation circuit 14 and the output of the high region generation circuit 28, and timing suit by the delay circuit 15. The audio signal output of a delay circuit 15, the low-pass interpolation signal output of the polynomial interpolation circuit 14, and the output of the high region generation circuit 28 are inputted into the synthetic circuit 24, and based on the noise detection result of the noise detector 26, the noise part of an audio signal is substituted for a interpolation signal, and is compounded.
[0045] Drawing 22 is drawing explaining the result of the gestalt 3 of this operation of operation, (a) expresses the original signal and the broken-line part shows between impulsive noise nascent states. (b) shows the result of operation by the gestalt 3 of this operation, compounds the low-pass interpolation signal which performed polynomial interpolation after high-frequency component removal, and the high region interpolation signal generated by the high region generation circuit based on the frequency called for by frequency analysis in the field in front of between impulsive noise nascent states, and is substituting it for the noise part of an audio signal.
[0046] In addition, although the gestalt 3 of operation explained the noise rejection to FM stereo signal, actuation is completely the same in the case of a monophonic signal only by the output of two lines of the FM demodulator circuit 5 completely serving as this signal. Moreover, since it is changeless to the processing after the audio signal output of the AM detector circuit 19 as shown in drawing 23 also to an AM signal, the configuration and actuation of a noise limiter circuit 29 are fundamentally the same.
[0047]
[Effect of the Invention] Since this invention is constituted as explained above, it does effectiveness as taken below so.
[0048] Since polynomial interpolation is carried out to low-pass [of an audio signal], it projects, does not become the interpolation signal carried out, and does not become discontinuity remarkably the between [nascent states] order of impulsive noise. Moreover, since both channels are interpolated independently after a stereo recovery, respectively, also when a difference is in the signal of both channels, gap is not produced before or after between [of impulsive noise] nascent states.
[0049] Since the last signal is read from memory to the high region of an audio signal and it compounds with a low-pass polynomial interpolation signal, compared with the case where it interpolates only on low-pass, the relation with the between [nascent states] order of impulsive noise can be made smooth.
[0050] Since a interpolation signal is generated from the frequency component in which it excelled [last] to the high region of an audio signal and it compounds with a low-pass polynomial interpolation signal, compared with the case where it interpolates only on low-pass, the relation with the between [nascent states] order of impulsive noise can be made smooth.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] Since in more detail removes the noise of the pulse nature resulting from an engine ignition plug, an engine window opening close drive motor, etc. in a car radio etc. with respect to noise rejection equipment, this invention uses it. Hereafter, this kind of noise is called "impulsive noise."

[Translation done.]

PRIOR ART

[Description of the Prior Art] Drawing 24 is drawing showing the configuration of the conventional pulse nature noise rejection equipment of a publication in JP,63-87026,A. In drawing, the delay circuit 2 where the detection signal outputted from the FM detector circuit 1 which considers FM intermediate frequency signal of an FM receiver as an input consists of LPF (low pass filter) is supplied, it is delayed, and the output of a delay circuit 2 is supplied to the stereo demodulator circuit 5 through a gate circuit 3 and the level hold circuit 4. Moreover, a detection signal is supplied to HPF6 for noise detection (high-pass filter), and the noise component signal which passed HPF6 is amplified with the noise amplifier 7, and is supplied to the noise detector circuit 8.
[0003] It consists of a rectifier circuit which rectifies the output signal of the noise amplifier 7, and this noise detection output is supplied to a waveform shaping circuit 9 and an integrating circuit 10, and the noise detector circuit 8 changes a noise detection output into the pulse of predetermined time amount width of face, and supplies a waveform shaping circuit 9 to a gate circuit 3. A gate circuit 3 will be driven, will be in a signal cut off state, and at the time of a signal cut off state, the delay output level in front of signal cutoff is held by the level hold circuit 4, and it is supplied to the stereo demodulator circuit 5 by the pulse supplied to the gate circuit 3 from the waveform shaping circuit 9. Generating of the spike by sudden change of potential is prevented by this.
[0004] Moreover, an integrating circuit 10 forms an AGC loop formation by graduating a noise detection output, acquiring the direct current signal according to a noise level, and feeding back to the noise amplifier 7. In addition, the delay circuit 2 is formed in order to compensate time amount after impulsive noise is supplied to HPF6 until it makes a gate circuit 3 into a cut off state. Moreover, since it is inputted in the form where balanced modulation of a Lch (left channel) signal and the Rch (right channel) signal was carried out by the frequency of 38kHz the core [(Lch+Rch)/2] as the stereo demodulator circuit 5 shows to drawing 25 , Lch and Rch are separated and taken out by carrying out time sharing, for example by 38kHz.
[0005] Drawing 26 is drawing showing actuation of conventional noise rejection equipment. Supposing it is a signal including impulsive noise (sign A) as the output signal of the FM detector circuit 1 shows to drawing 26 (a), the signal which the high-frequency component of the output signal of the FM detector circuit 1 is extracted by HPF6, and is shown in this drawing (b) will be acquired. It is amplified with the noise amplifier 7 and rectified by the noise detector circuit 8, and the output signal of this HPF6 is changed into the pulse of predetermined time amount width of face as a waveform shaping circuit 9 shows to this drawing (c). The period of the impulsive noise of the predetermined signal time delay carried out is controlled by the gate circuit 3 to a cut off state to be shown in this drawing (e) so that a delay circuit 2 shows to this drawing (d). In the level hold circuit 4, as shown in this drawing (f), when the level in front of cutoff holds the cutoff period of gate circuit 3 output, the impulsive noise which suited the signal of a basis is removed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since this invention is constituted as explained above, it does effectiveness as taken below so.
[0048] Since polynomial interpolation is carried out to low-pass [of an audio signal], it projects, does not become the interpolation signal carried out, and does not become discontinuity remarkably the between [nascent states] order of impulsive noise. Moreover, since both channels are interpolated independently after a stereo recovery, respectively, also when a difference is in the signal of both channels, gap is not produced before or after between [of impulsive noise] nascent states.
[0049] Since the last signal is read from memory to the high region of an audio signal and it compounds with a low-pass polynomial interpolation signal, compared with the case where it interpolates only on low-pass, the relation with the between [nascent states] order of impulsive noise can be made smooth.
[0050] Since a interpolation signal is generated from the frequency component in which it excelled [last] to the high region of an audio signal and it compounds with a low-pass polynomial interpolation signal, compared with the case where it interpolates only on low-pass, the relation with the between [nascent states] order of impulsive noise can be made smooth.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As shown in drawing 27 (a) and (b), when impulsive noise is removed since conventional pulse nature noise rejection equipment was constituted as mentioned above, but a signal has a certain amount of amplitude, it does not mean a signal's becoming discontinuity immediately after maintenance, although it is last value maintenance therefore, and fully removing a noise. Moreover, although it is last value maintenance when a high frequency component is included, as shown in drawing 27 (c) therefore, a signal may become discontinuity maintenance order, and existence of an audibility top noise rejection processing part may be conspicuous. Furthermore, when a difference was in the signal of both channels as shown in drawing 27 (d) since before value maintenance processing was performed before the stereo recovery, there were troubles, such as producing the part which changes greatly to processing order in channel of one of the two with last value maintenance.
[0007] This invention was made in order to solve the above troubles, it removes impulsive noise from the audio signal after a stereo recovery certainly, and also when a high frequency component is moreover included, it aims at not producing discontinuous [of a removal part and order].

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block circuit diagram showing the configuration of the gestalt 1 of operation of this invention.
[Drawing 2] It is the explanatory view of 3rd formula interpolation of the gestalt 1 of operation.
[Drawing 3] It is the explanatory view of 3rd formula interpolation of operation to a signal including the high-frequency component of the gestalt 1 of operation.
[Drawing 4] It is an explanatory view of operation at the time of using LPF to a signal including the high-frequency component of the gestalt 1 of operation.
[Drawing 5] It is drawing showing the configuration of the example of the polynomial interpolation circuit of the gestalt 1 of operation.
[Drawing 6] It is the explanatory view of the example of the polynomial interpolation circuit of the gestalt 1 of operation of operation.
[Drawing 7] It is the explanatory view of the synthetic circuit of the gestalt 1 of operation of operation.
[Drawing 8] It is the explanatory view of the gestalt 1 of operation of operation.
[Drawing 9] It is the block circuit diagram showing other configurations of the gestalt 1 of operation.
[Drawing 10] It is the block circuit diagram showing the configuration of the gestalt 2 of operation of this invention.
[Drawing 11] It is an explanatory view of operation for high region interpolation of the gestalt 2 of operation.
[Drawing 12] It is the explanatory view of the phase doubling approach of high region interpolation of the gestalt 2 of operation.
[Drawing 13] It is drawing showing the configuration of the example of the high region interpolation circuit of the gestalt 2 of operation.
[Drawing 14] It is drawing showing the configuration of the example of the synthetic circuit of the gestalt 2 of operation.
[Drawing 15] It is a timing chart concerning explanation of the gestalt 2 of operation of operation.
[Drawing 16] It is the explanatory view of the gestalt 2 of operation of operation.
[Drawing 17] It is the block circuit diagram showing other configurations of the gestalt 2 of operation.
[Drawing 18] It is the block circuit diagram showing the configuration of the gestalt 3 of operation of this invention.
[Drawing 19] It is the explanatory view of the frequency analysis of the gestalt 3 of operation of operation.
[Drawing 20] It is drawing showing the configuration of the example of the frequency-analysis circuit of the gestalt 3 of operation, and a high region generation circuit.
[Drawing 21] It is a timing chart concerning explanation of the gestalt 3 of operation of operation.
[Drawing 22] It is the explanatory view of the gestalt 3 of operation of operation.
[Drawing 23] It is the block circuit diagram showing other configurations of the gestalt 3 of operation.
[Drawing 24] It is the block circuit diagram showing the configuration of conventional pulse nature

noise rejection equipment.
[Drawing 25] It is the explanatory view of the stereo demodulator circuit of the conventional example of operation.
[Drawing 26] It is the explanatory view of the conventional example of operation.
[Drawing 27] It is drawing explaining the technical problem of the conventional example.
[Description of Notations]
1 FM detector circuit, 5 A stereo demodulator circuit, 11 A noise detector, 12 A delay circuit, 13 LPF, 14 A polynomial interpolation circuit, 15 A delay circuit, 16, 24 composition circuits, 17, 18, 25, 26, 29, 30 A noise limiter circuit, 20 A noise detector, 21 HPF, 22 Memory, 23 A quantity region interpolation circuit, 27 A frequency-analysis circuit, 28 Quantity region generation circuit.

[Translation done.]

* NOTICES *

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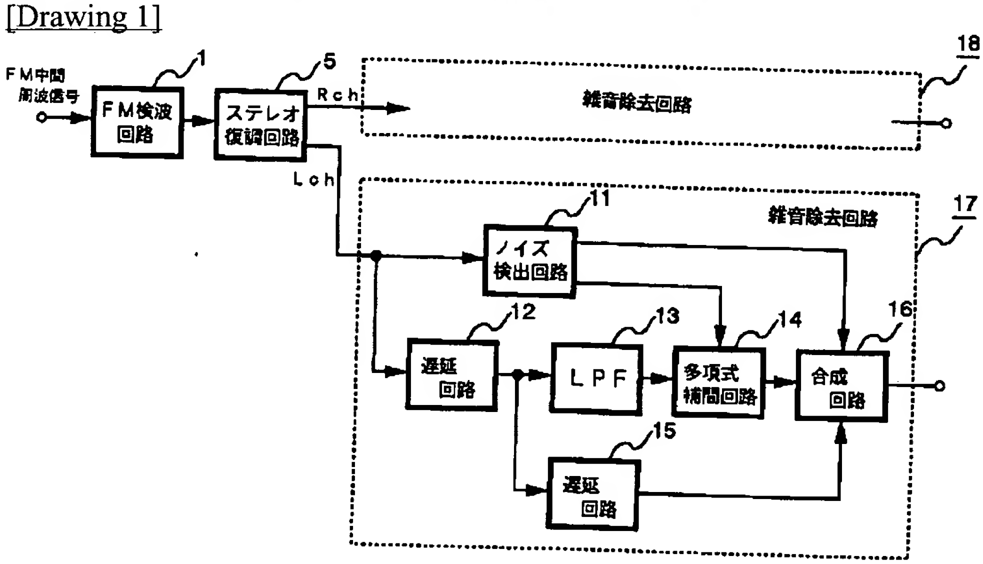
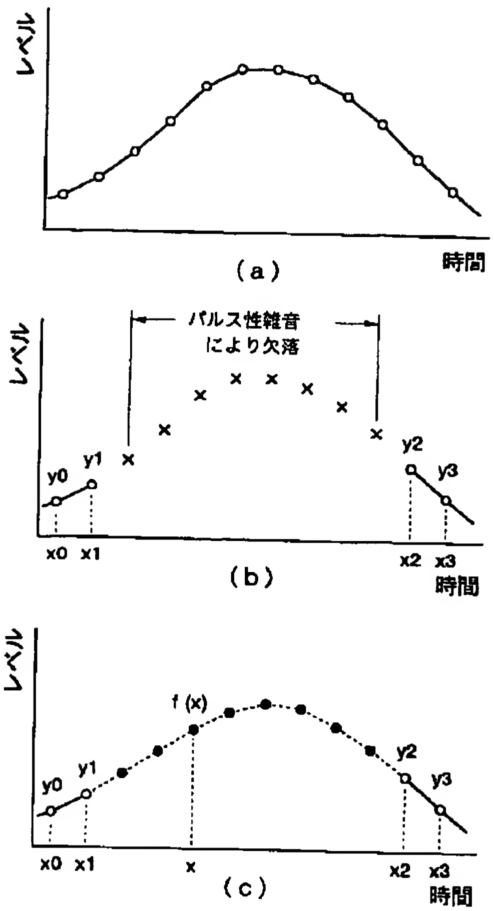
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

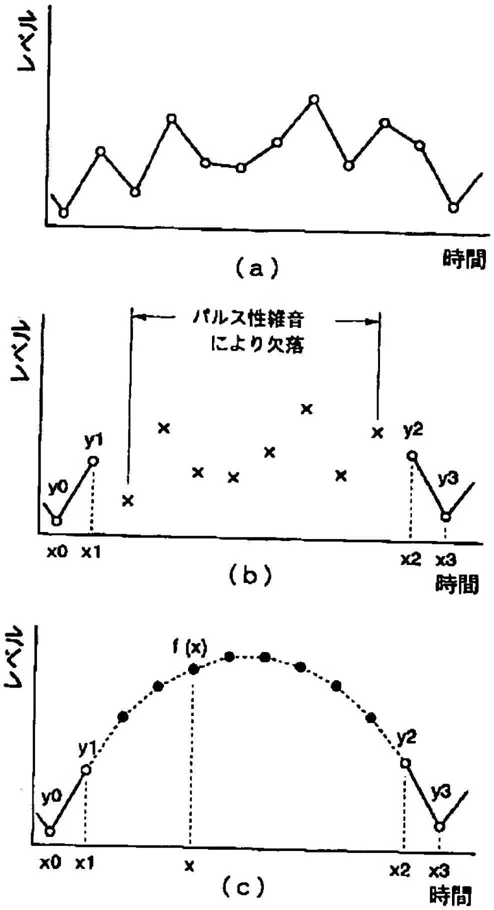
[Drawing 1]



[Drawing 2]

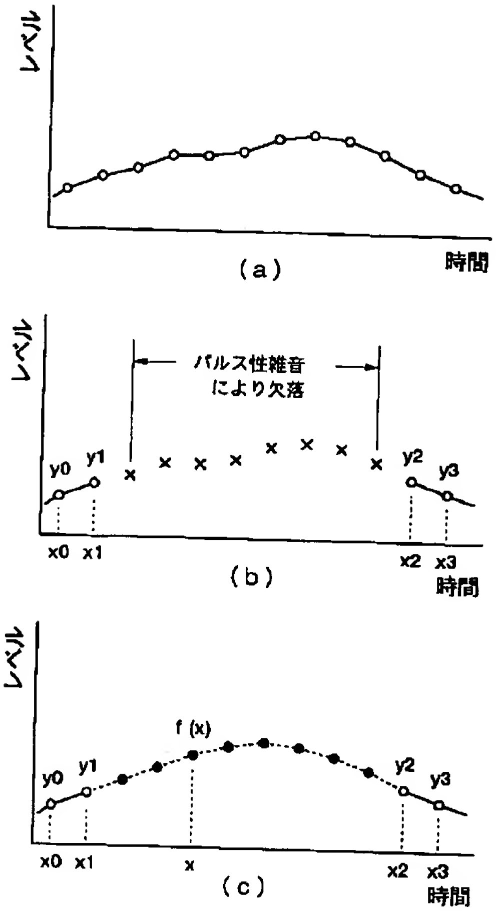

レベル
時間
(a)
レベル
パルス性雑音
により欠落
y0
y1
y2
y3
x0
x1
x2
x3
時間
(b)
レベル
f (x)
y0
y1
y2
y3
x0
x1
x
x2
x3
時間
(c)

[Drawing 3]



レベル
時間
(a)
レベル
パルス性雑音
により欠落
y0
y1
y2
y3
x0
x1
x2
x3
時間
(b)
レベル
f (x)
y0
y1
y2
y3
x0
x1
x
x2
x3
時間
(c)

[Drawing 4]



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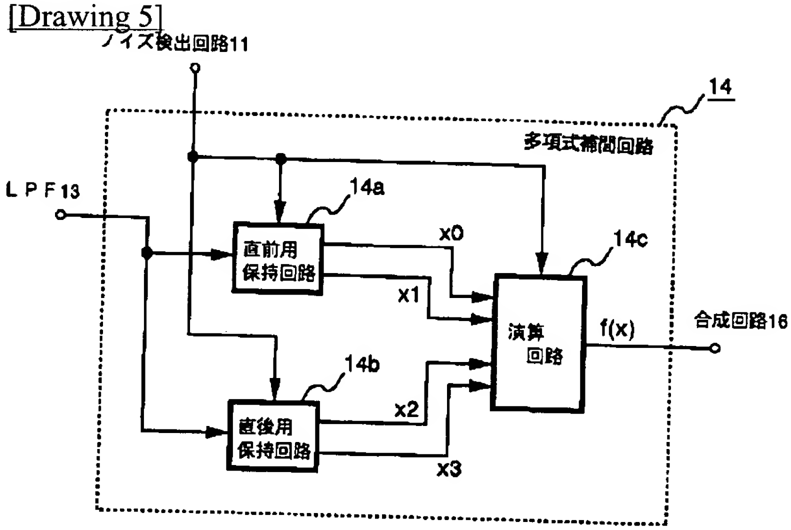

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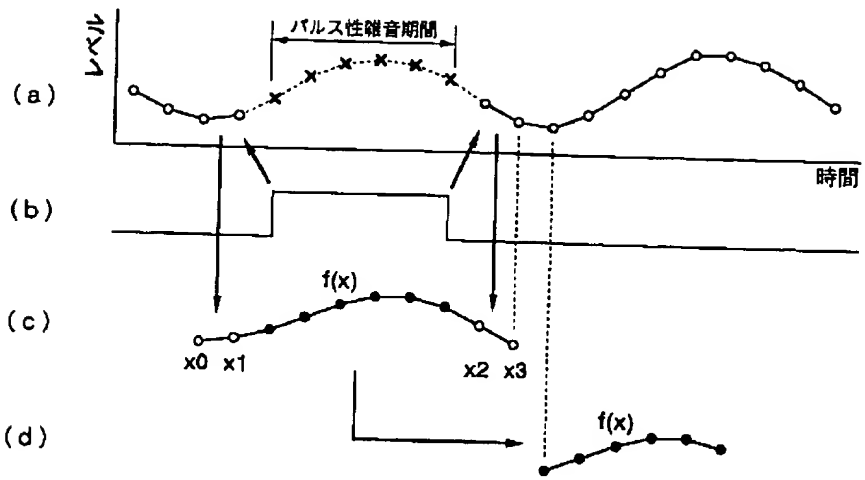

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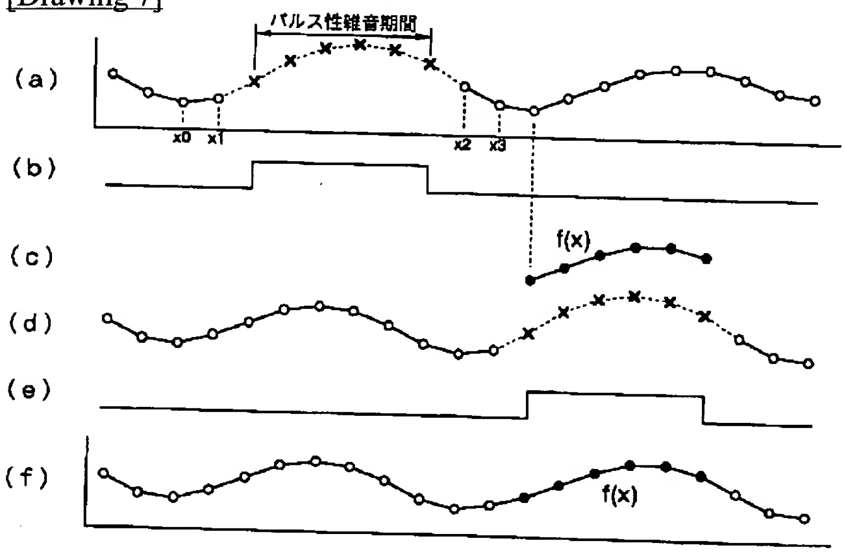

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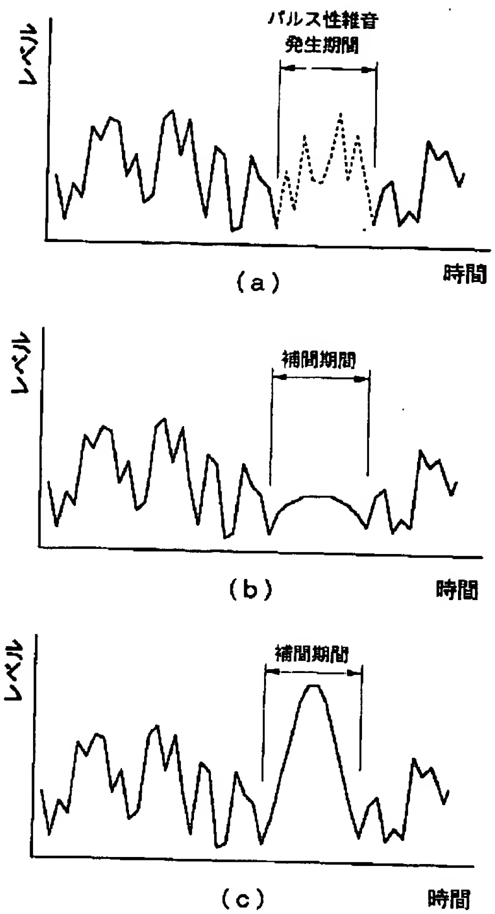

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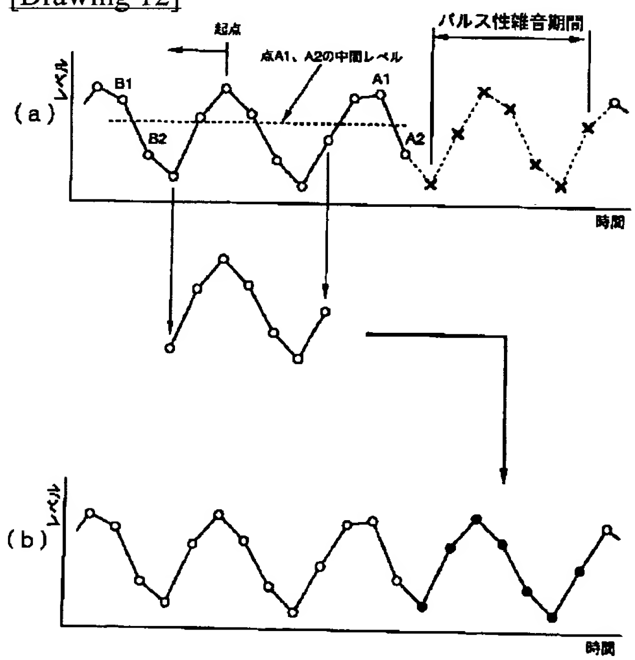

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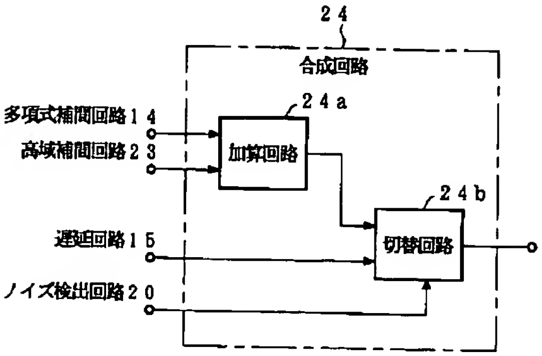

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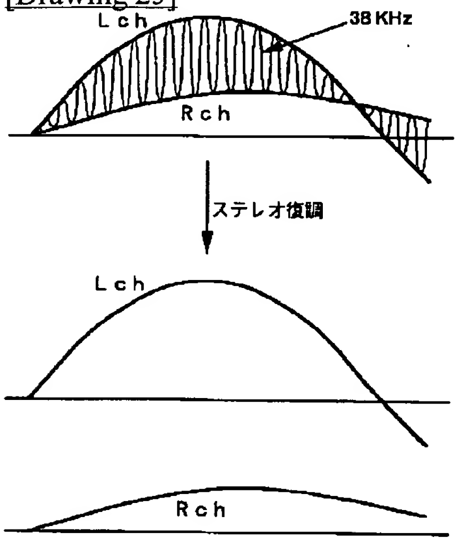
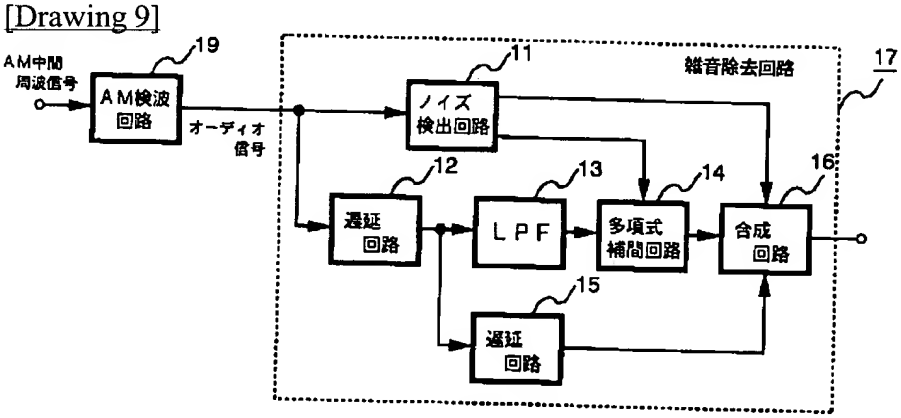


[Drawing 9]



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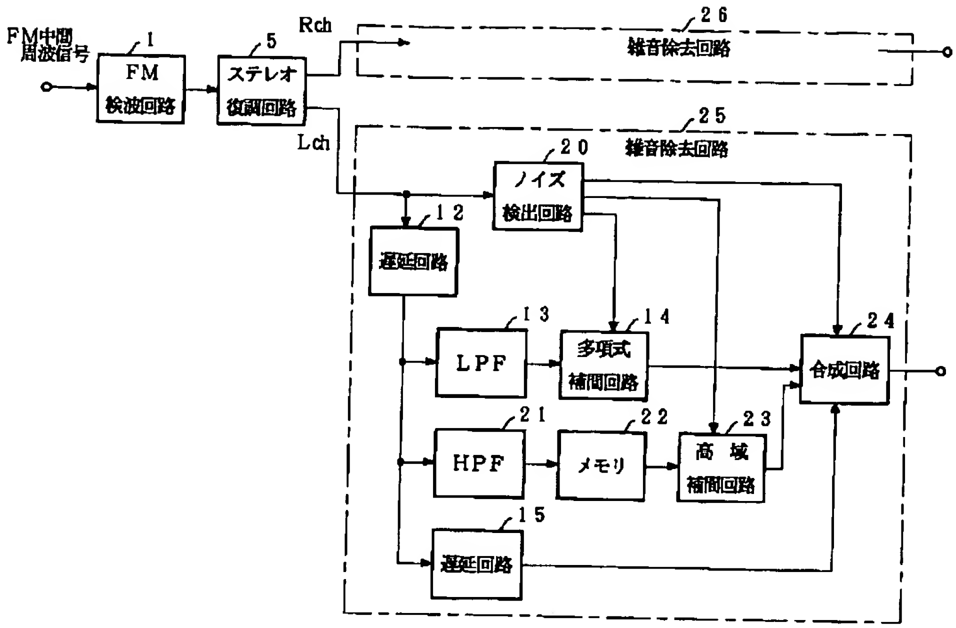

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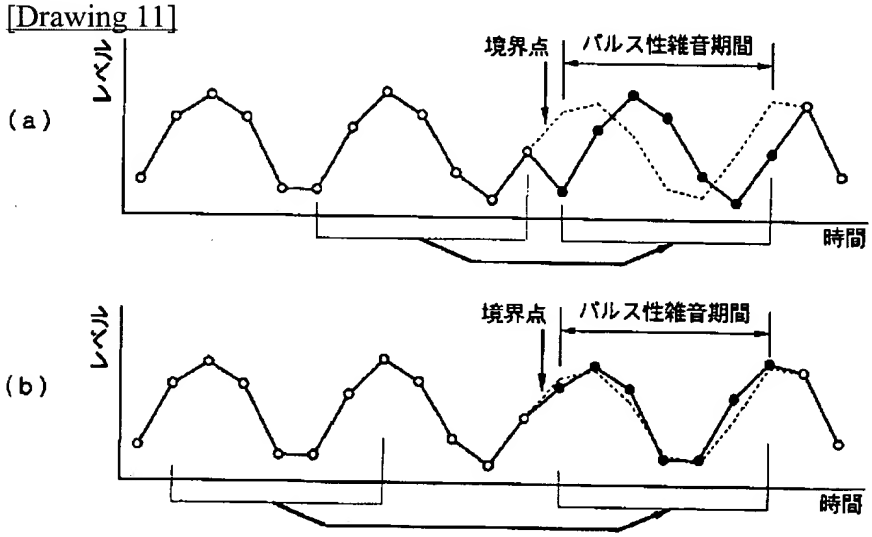
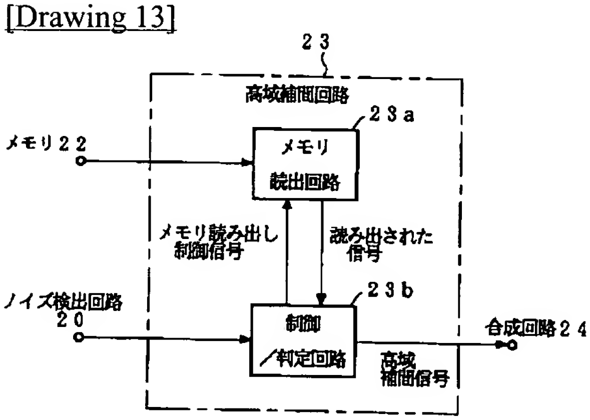


[Drawing 13]



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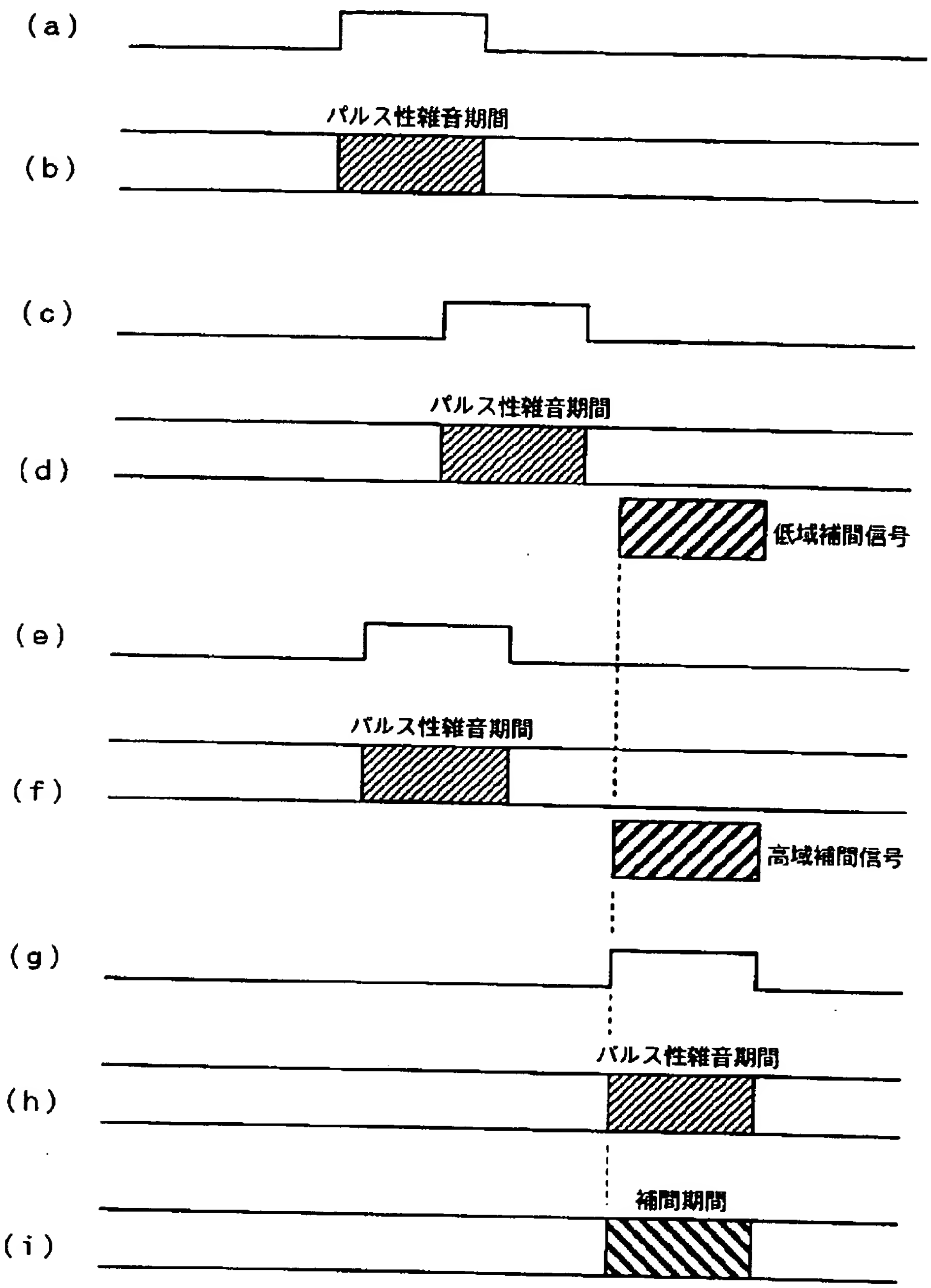
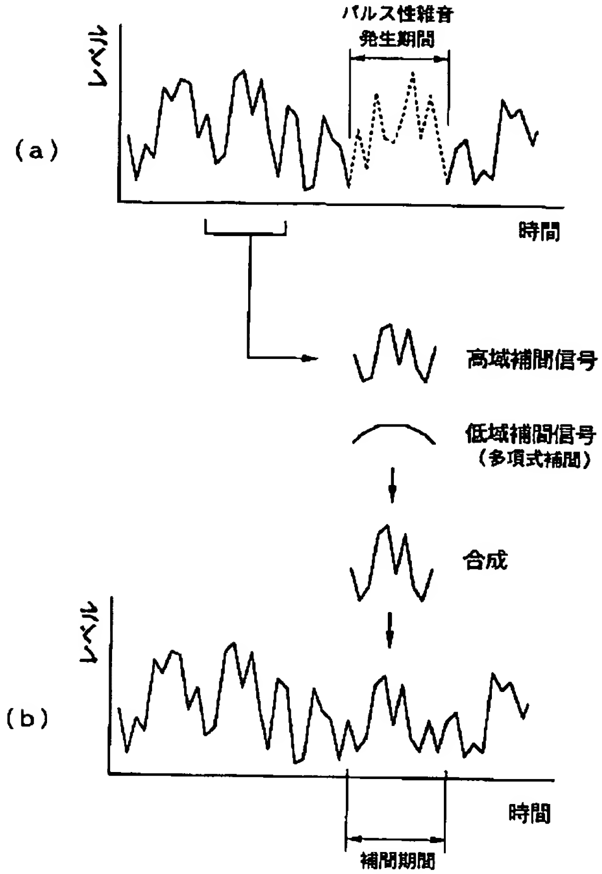
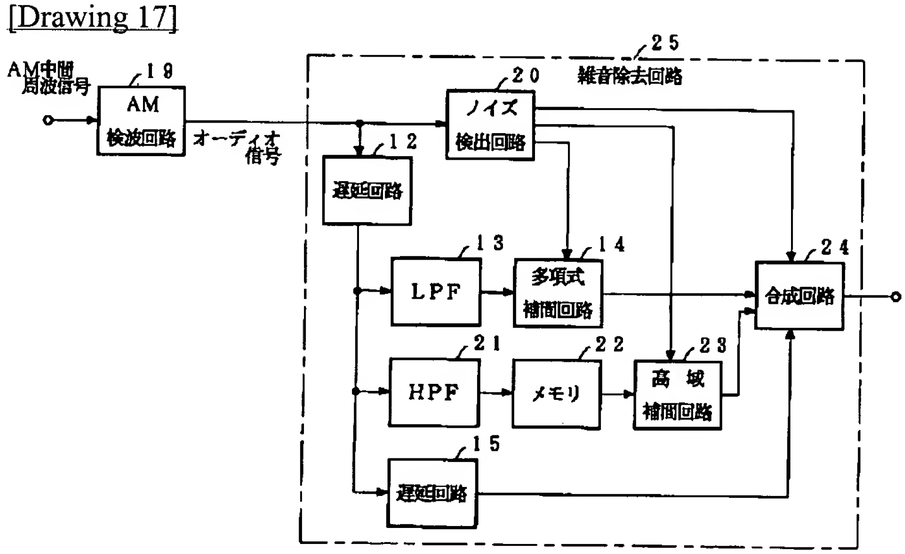

(a)
パルス性雑音期間
(b)
(c)
パルス性雑音期間
(d)
低域補間信号
(e)
パルス性雑音期間
(f)
高域補間信号
(g)
パルス性雑音期間
(h)
補間期間
(i)

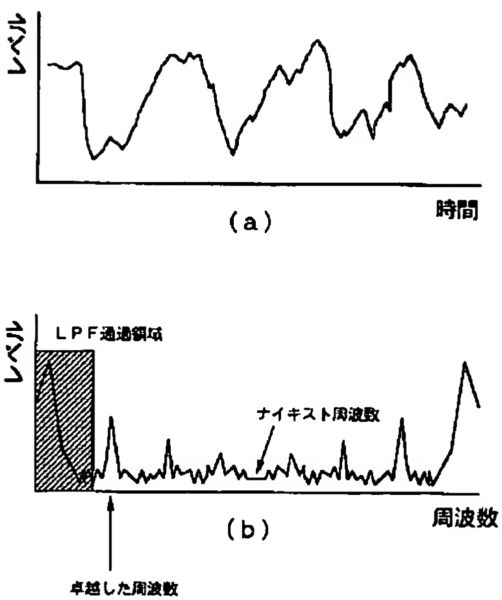
[Drawing 16]



[Drawing 17]



[Drawing 19]



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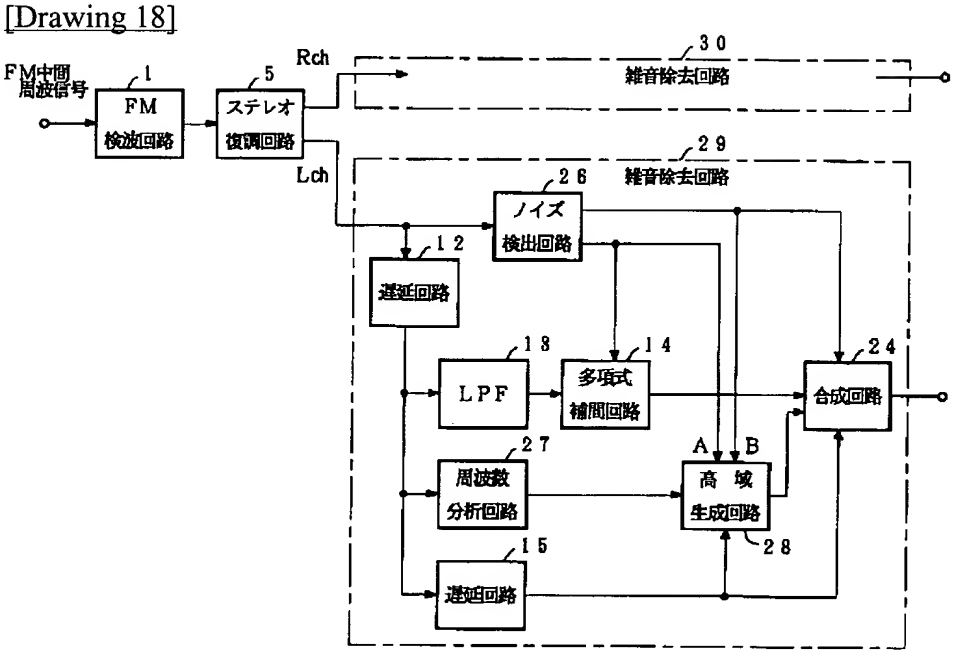
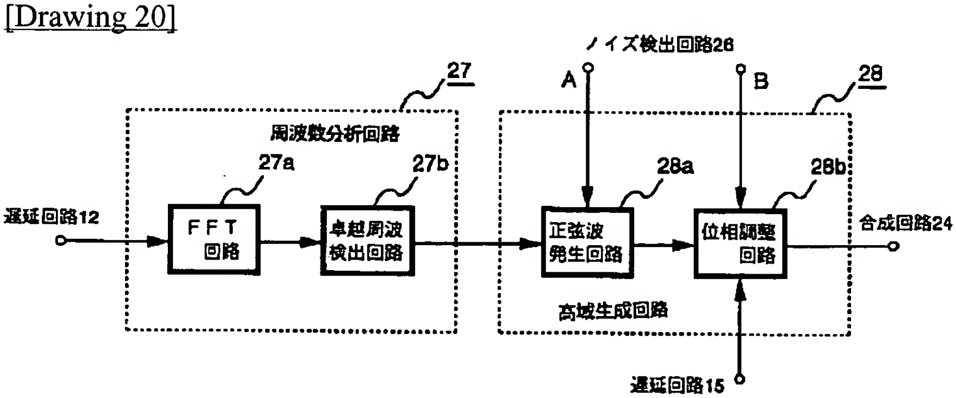
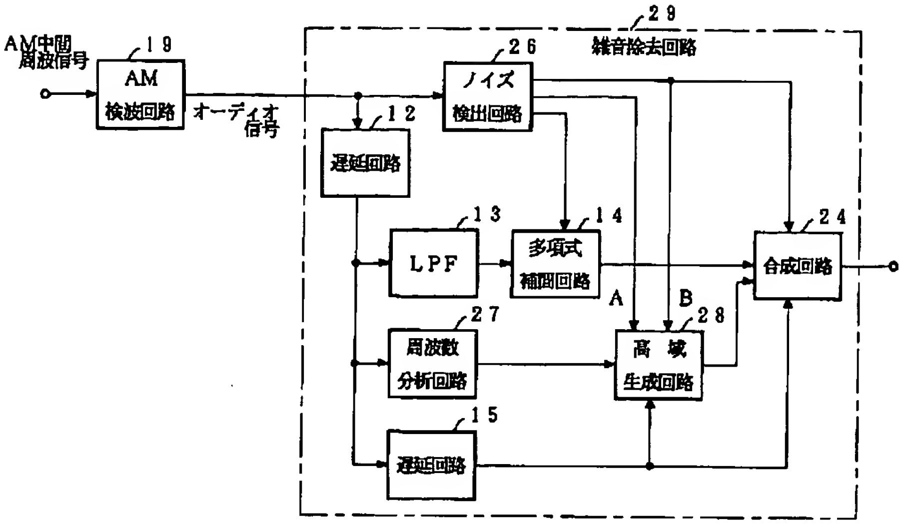


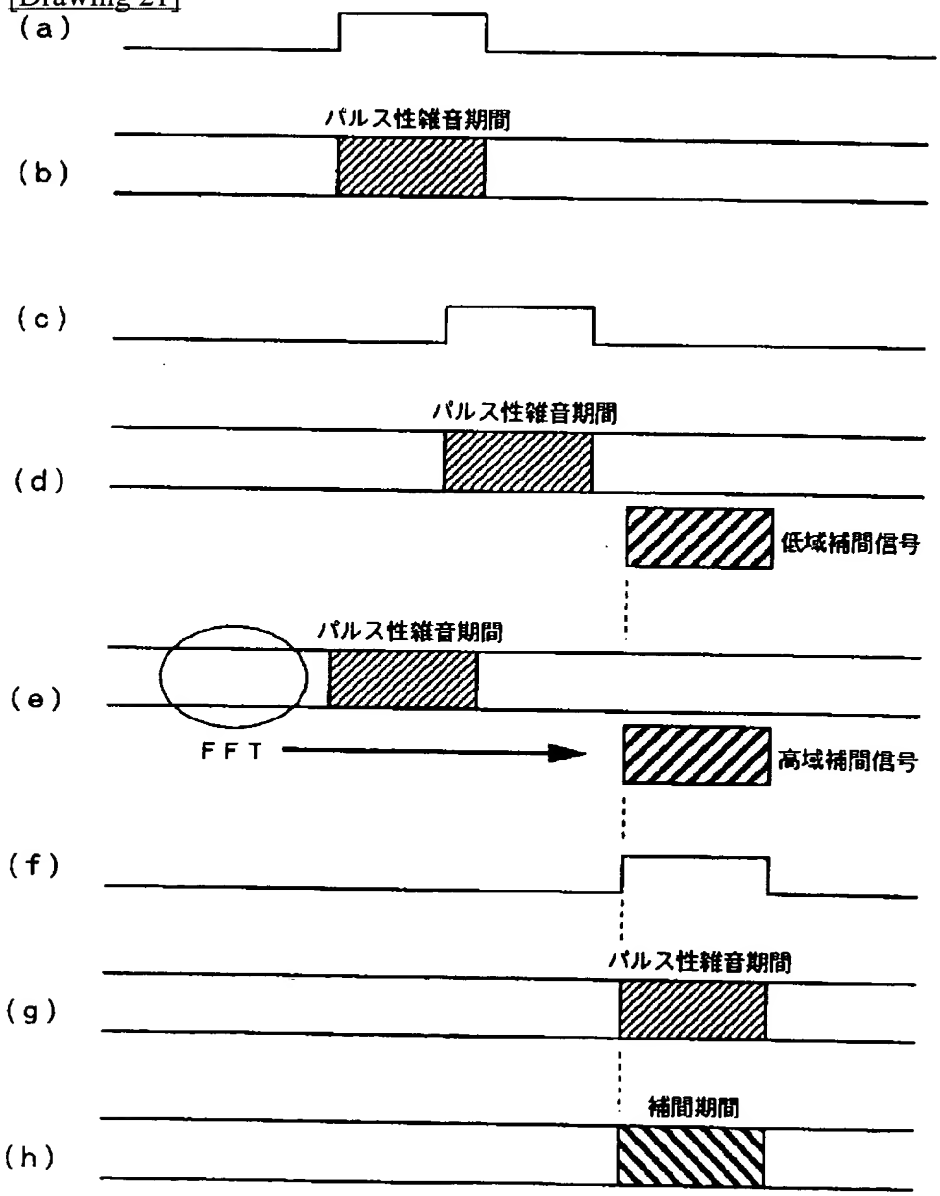
[Drawing 20]



[Drawing 23]


AM中間周波信号
19
AM検波回路
オーディオ信号
29
雑音除去回路
26
ノイズ検出回路
12
遅延回路
13
LPF
14
多項式補間回路
24
合成回路
A
B
27
周波数分析回路
28
高域生成回路
15
遅延回路

[Drawing 21]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パルス性雑音期間
(b)
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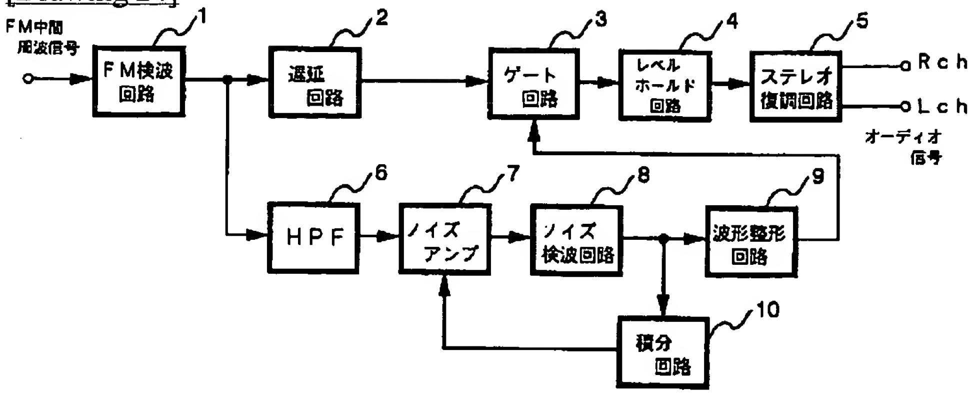
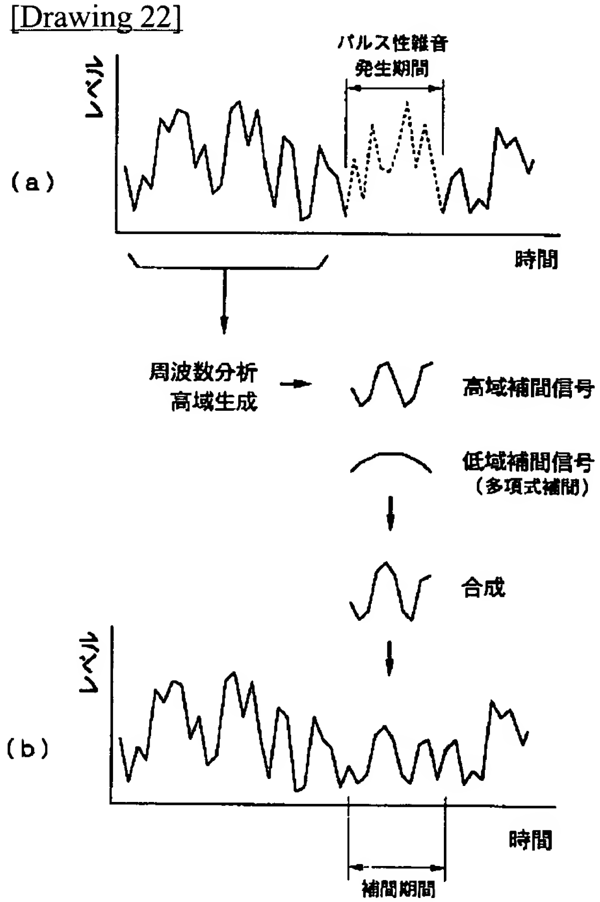
(g)
補間期間
(h)

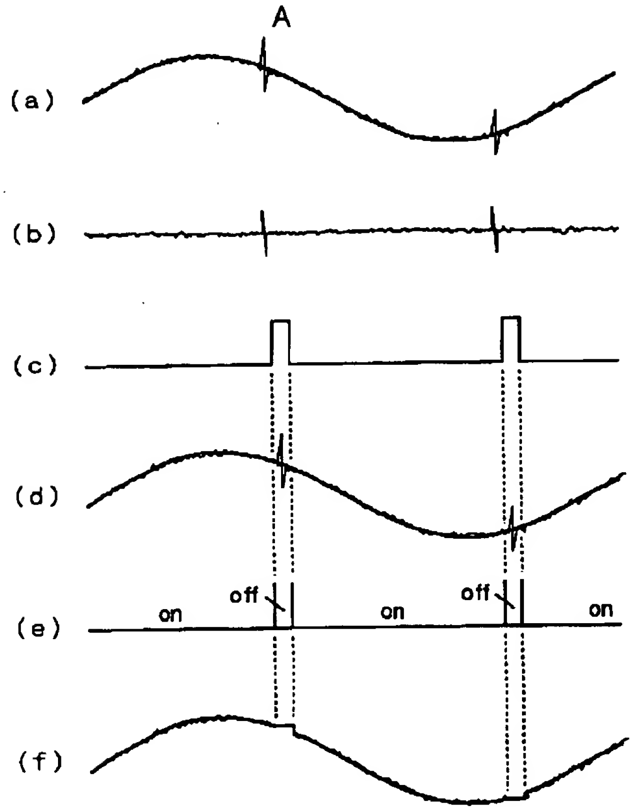
[Drawing 24]



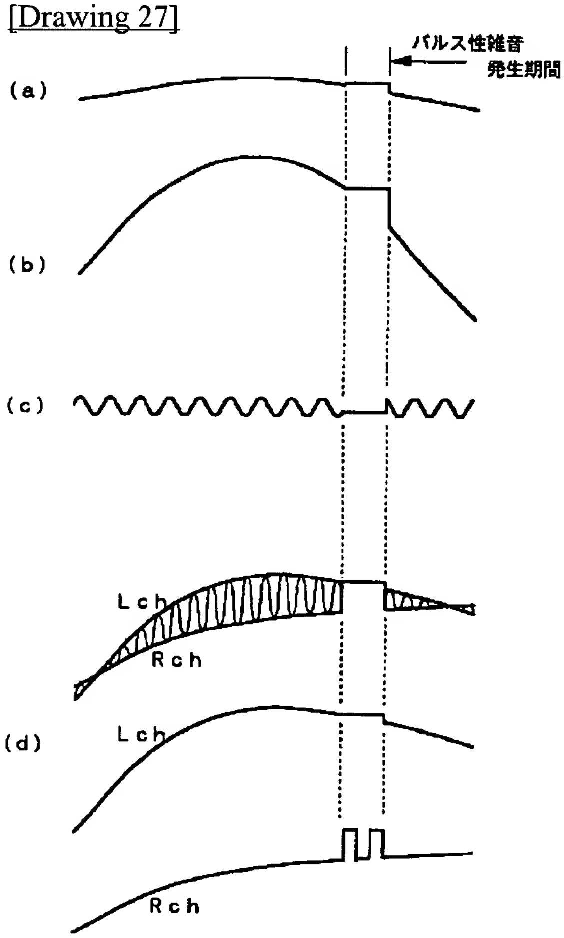
[Drawing 22]



[Drawing 26]



[Drawing 27]



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